California Regional Water Quality Control Board
Central Valley Region

Linda S. Adams
Secretary for Environmental Protection

Redding Office
415 Knollcrest Drive, Suite 100, Redding, California 96002
(530) 224-4845 • Fax (530) 224-4857
http://www.waterboards.ca.gov/centralvalley

Arnold Schwarzenegger
Governor

TO: JAMES ROHRBACH
Water Resource Control Engineer

FROM: PHILIP WOODWARD, CEG, CHG
Senior Engineering Geologist

DATE: 13 September 2006

SIGNATURE: ________________________

SUBJECT: COMMENTS ON PLACEMENT OF MONITORING WELLS NEAR GEOTHERMAL PRODUCTION WELL NO. 31-17, TELEPHONE FLAT GEOTHERMAL EXPLORATION AND DEVELOPMENT PROJECT, SISKIYOU COUNTY, CALIFORNIA

The Regional Water Quality Control Board, Central Valley Region (Regional Board) has drafted tentative waste discharge requirements (WDRs) for the Calpine Corporation's (Calpine) Telephone Flat Geothermal Project. I have been requested to provide comments on the placement of three shallow groundwater-monitoring wells, and the appropriateness and placement of one deep groundwater monitoring well near Geothermal Production Well No. 31-17 (Well No. 31-17). This monitoring system is to be limited to the area of Well No. 31-17 and does not include groundwater monitoring of the entire Telephone Flat Geothermal Project nor the production phase of the project. Included in my task is a review of the report titled *Review Of The Hydrology Monitoring Plan, Telephone Flat Geothermal Project, Siskiyou County, California*, dated 5 May 2006, prepared by Calpine Corporation's consultant, Earth Systems Southwest (ESSW).

BACKGROUND

Specific documents used in my review include confidential information provided to the Regional Board by CalEnergy Company, Inc. in 1998, including the following documents:

1) Letter from CalEnergy to Ms. Meg MacDonald, WESTEC that includes:

   a) Lithology ("mud logs") and static temperature surveys to about 2500 to 3500 feet below ground surface (bgs) for temperature gradient boreholes ML 87-13, ML 84-17, ML 52-30, and ML 65-26, and deep test wells GMF 68-8, GMF 31-17, and GMF 87-13.
   b) Report from CalEnergy to the U.S. Department Of Interior, Bureau Of Land Management dated 15 August 1996.
   c) A summary of data from Well No. GMF 31-17, which includes a generalized geologic log to 8787 feet bgs, as well as static temperature and pressure profiles to 4000 feet bgs.
   d) Three generalized geologic cross sections through Medicine Lake Volcano.

e) Three generalized alteration and temperature cross-sections through Medicine Lake Volcano.

2) Tentative Waste Discharge Requirements for Calpine Siskiyou Geothermal Partners, L.P., And CPN Telephone Flat, Inc., U.S. Department Of Agriculture, Forest Service and U.S. Department Of Interior, Bureau Of Land Management Glass Mountain Unit Geothermal Exploration and Development Projects, Shasta County, dated May 2006.
3) United States Geological Survey (USGS) Open File Report 98-777, *3-Diminsional Visualization of the Medicine Lake Highlands, CA: Topography, Geology, Geophysics and Hydrology.*

Documents which I read several years ago and influenced this review include those listed below:

4) Confidential documents provided by CalEnergy in 1998 including copies of overhead slides used in a presentation to agencies, memo on the perforation of Medicine Lake stratigraphic test holes, geochemistry data and isotope data on various water bodies.
5) CalEnergy Plan of Operations: August 1996 and May 1997.
6) Calpine Plan of Operations, 1997.
7) Telephone Flat Geothermal Development Project Final Environmental Impact Statement, January 1999.
8) California Regional Water Quality Control Board, Central Valley Region, Waste Discharge Requirements for California Energy General Corporation Board Order No. 95-199, August 1995.
9) USGS Open File Report 95-750, *Hydrologic Data and Description of a Hydrologic Monitoring Plan for Medicine Lake Volcano*, California, 1995.
10) Mariner, R.H., and Lowernsten, J.B., 1999, *The Geochemistry of Waters from Springs, Wells and Snowpack on and Adjacent to Medicine Lake Volcano, Northern California*: Transactions Geothermal Resources Council, v. 23, p. 319-326.
11) Weiss Associates, *Baseline Hydrogeology Evaluation Report for Telephone Flat Geothermal Project, Medicine Lake, California*, August 1997.
12) Glass Mountain Unit Geothermal Exploration Project EA/IS, August 1995.

ESSW'S REVIEW

The ESSW review contains an extensive analysis of past studies done on the Medicine Lake Highlands (MLH) hydrogeology.

In Section 4.2 Hydrologic Setting, ESSW describes three major hydrologic units believed to comprise the MLH and outlined by a previous investigator, Weiss (1997). Briefly, these units are:

Hydrologic Unit 1 (HU-1) is the first encountered shallow and perched groundwater-bearing zone. It is contained within the Medicine Lake Volcano rocks and would be the first groundwater impacted by contaminants originating from the surface. It could also become contaminated if leaks occur in the geothermal wells that pass through this unit and convey the geothermal fluids from the heated subsurface reservoir to the surface. It may be up to 400 feet thick.

Hydrologic Unit 2 (HU-2) comprises the regional groundwater contained within the pre-Medicine Lake Volcano rocks. As such this unit is relatively deep. Contamination from surface discharges would have little impact on this area, however if leaks occur in the geothermal wells in this interval, this groundwater could be adversely impacted.

Hydrologic Unit 3 (HU-3) is the deepest unit and comprises the geothermal reservoir itself.

Based on their review of the data, ESSW contends that in the Telephone Flat Geothermal Project Area, HU-2 does not exist and has been incorporated into HU-3. While I have only reviewed well logs within the Telephone Flat Geothermal Project Area, my review does not contradict this conclusion.

Also, ESSW concludes that HU-3 is isolated from HU-1 in the project area by a “caprock” comprised of highly altered volcanic rock. Such alteration results in the original crystalline rock, which may contain interlayers or fractures capable of transmitting large quantities of water, being altered to clay and other minerals with low permeabilities, which would inhibit such water movement. This conclusion is supported by 1) the distinctive increase in the geothermal gradient from a generally isothermal regime in HU-1 to a rapid increase in temperature over a relatively short depth until the geothermal reservoir is approached, and 2) by the lack of surface expression of hot springs or other thermal features. The only thermal feature noted in the MLH is the Hotspot near Glass Mountain, a few miles northeast of the site. Information on the gas chemistry of this feature indicates its source is not from the geothermal reservoir, but meteoric water that has been heated, possibly from residual head from the Glass Mountain flow. Again, my review of the data supports this conclusion.

Additionally, as a consequence of the caprock presence and isolation of the geothermal reservoir in the project area, it is unlikely that significant quantities of the geothermal fluids contained in the reservoir make their way to the freshwater springs at Fall River. Further, the work of other investigators, including scientists with the USGS, indicates the Medicine Lake Basin is not capable of contributing significant quantities of water to the Fall River Springs. Therefore, if a leak or spill were to occur at the Telephone Flat Geothermal Project, it is unlikely it would impact the springs. These investigations are described and referenced in the ESSW report and the Hydrology Monitoring Plan contained in the tentative WDRs and, for brevity, are not repeated here.

The ESSW report recommends construction of three shallow groundwater monitoring wells and omitting the deep monitoring well in Section 6.0 NEW WELL LOCATIONS AND CONSTRUCTION.

COMMENTS ON THE ESSW REVIEW OF THE HYDROLOGY MONITORING PLAN

Items in need of explanation or refinement include:

1) Number of monitoring wells required and placement
2) Groundwater flow direction
3) Depth to shallow groundwater
4) Appropriate well drilling methodology
5) Well screen interval
6) Necessity for deep groundwater monitoring

These items are discussed in detail below.

SHALLOW GROUNDWATER MONITORING

The purpose of shallow groundwater monitoring at the site is to detect, at the earliest time possible, any impacts to groundwater that originate at the ground surface. Wells must be placed downgradient of potential source areas. In this case, not only is the local direction of groundwater flow unknown, the actual depth to shallow groundwater is unknown. Assumptions are made by ESSW as to the direction and depth which are useful in planning the location the initial wells, however as data is developed, it is possible additional wells will be necessary to provide for effective coverage of the site.

For a groundwater monitoring system to be effective in detecting impacts from surface sources, the wells should be screened across the water table. Screen lengths must be limited to reduce the dilution potential from uncontaminated water deeper in the water-bearing zone. Such dilution may result in the waste constituent concentrations being diluted below the detection limit, thus delaying identification of groundwater degradation. Limiting well screen lengths also reduces the potential for the well to act as a conduit for contamination, allowing waste constituents to move rapidly downward into uncontaminated zones that would otherwise be unaffected. To this end, screen lengths should be limited to no greater than 20 feet with two feet of additional filter pack above the screen, not the 60 feet of screen and 10 feet of additional filter pack proposed by ESSW.

It is imperative that the depth to first encountered groundwater be carefully identified. This cannot be done with a mud-rotary rig as proposed by ESSW, because the circulating mud would likely obscure detection of the first encountered groundwater. The wells should be drilled using an air-rotary rig so the depth to first groundwater can be accurately measured and the top of the well screen appropriately situated. With an air-rotary rig, production intervals (usually the intervals between individual lava flows) can be easily evaluated for the volume of water they are capable of transmitting. Further, well development is easier because mud and drilling fluids do not have to be removed from the formation or filter pack.

The materials used to construct the well should be selected so that they do not contribute constituents identical to those being used to detect a release of wastes. Therefore, PVC and not metal may be the material of choice.

The proposed well spacing, up to and even over a mile apart, is quite large and not suitable for detecting discharges from a single well pad. The groundwater gradient in the area of the project may have local variations that cannot be detected with the large spacing proposed between wells. The result of these conditions is that a contaminant may move in an unexpected direction from that calculated, resulting in a useless detection system.

The above situation is exacerbated due to the fact that groundwater-monitoring wells also have a very limited area of detection. If a contaminant is spilled a few tens of yards beyond the well, it may not be detected.

The three wells should be located in close proximity, (10's of yards if possible) from the potential sources of contaminants, with two of the wells placed in the predicted downgradient direction.

The proposed wells should be offset from a linear alignment as much as practical to allow for a more accurate triangulation of the groundwater gradient.

In summary, the development of a shallow groundwater monitoring system may be an iterative process. An initial three wells, screened over the water table and with limited screen lengths should be installed and information gathered for a period of time. Based on the information gathered during this time, additional wells may be necessary to assure rapid detection of a release of waste constituents from the surface.

DEEP GROUNDWATER MONITORING

The ESSW analyses concludes that since the intermediate water bearing zone HU-2 does not exist beneath the project site, deep groundwater monitoring in not necessary. This conclusion ignores the Regional Board's rational for requiring deep groundwater monitoring. The shallow groundwater monitoring system should be designed to monitor only the shallowest groundwater, perhaps the first 20 to 50 feet bgs. A deep monitoring system should be designed to detect contamination from a possible leak in a geothermal well at the deepest possible point where useable, non-geothermal groundwater is shown to exist. This may be hydraulic unit HU-1, albeit several hundred feet below the water table and shallow monitoring system.

Further support for a deep well in HU-1 is the fact that vertical groundwater flow is restricted by the lateral nature of lava flows. The preferred direction of groundwater flow is predominantly horizontal along the interflow boundaries. Thus developing a monitoring system relaying on shallow monitoring only is virtually guaranteed to miss any deeper contamination originating from a deep source, such as a leak in a geothermal well at depth.

Using a single deep groundwater monitoring well to monitor potential effects deeper in the water bearing zone will not provide adequate coverage unless the groundwater flow direction is precisely known and a single well can be placed confidently to intercept the flow from the potential contamination source. However, currently this data does not exist. As with a shallow monitoring system, a minimum of three deep wells, screened over the same water bearing zones are necessary to determine groundwater flow direction. Once the groundwater flow direction is established then it can be determined if at least one of the wells is downgradient of the potential pollution source and is capable of detecting such pollution.

I contacted Bruce Carlton and Joe Biel of Calpine on 11 September 2006, with a question on the relative hydraulic head between the geothermal reservoir and the upper water-bearing zone. Mr. Biel stated he believed the static level in the geothermal reservoir was less than the upper freshwater bearing zone, however it had been some time since he had reviewed the data and could not provide details. It therefore follows, that when the well is shut in, any leakage into the well would be from the upper water-bearing zone downward into the geothermal zone.

However, during either acidification or production operations when the well by necessity is pressurized, the gradient would reverse and fluids from the well bore could enter the upper water-bearing zone if a leak were to occur. While a small leak of a few gallons per minute may not cause a noticeable pressure loss in the well which could be detected by operators on the surface, over time such a leak would have the potential to inject a significant quantity of saline waste into water with relatively low total dissolved solids (TDS) concentration in the upper zone. With an adequate deep monitoring system, such an increase in TDS would be detected relatively rapidly and corrective actions taken.

In locating the deep groundwater monitoring well(s), the same principles apply as to the shallow system. An initial suite of three wells should be installed near potential contamination sources (the geothermal wells) and data gathered for a period of time. After data interpretation and determination of the groundwater flow direction, additional wells may be necessary.

PVW: reb

U:\Clerical Documents\SA_Correspondence\WoodwardP\sep 06\Editorialcommentsteleflatdraft.doc